PATENT COOPERATION TREATY

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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference UVD0323 PB	**FOR FURTHER ACTION** See Form PCT/IPEA/416	
International application No. PCT/US2004/034266	International filing date *(day/month/year)* 15.10.2004	Priority date *(day/month/year)* 20.10.2003
International Patent Classification (IPC) or national classification and IPC H01P1/10, H01P1/18		
Applicant UNIVERSITY OF DAYTON ET AL.		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 6 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *sent to the applicant and to the International Bureau)* a total of 5 sheets, as follows:
      - ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      - ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.

   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

☒	Box No. I	Basis of the opinion
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☒	Box No. VIII	Certain observations on the international application

Date of submission of the demand 19.08.2005	Date of completion of this report 08.09.2005
Name and mailing address of the international preliminary examining authority: European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized Officer Pastor Jiménez, J-V Telephone No. +31 70 340-4965

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/US2004/034266

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
   - ☐ international search (under Rules 12.3 and 23.1(b))
   - ☐ publication of the international application (under Rule 12.4)
   - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages

1-11 as originally filed

Claims, Numbers

1-32 received on 19.08.2005 with letter of 16.08.2005

Drawings, Sheets

1/12-12/12 as originally filed

☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

* *If item 4 applies, some or all of these sheets may be marked "superseded."*

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-32
	No:	Claims	
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-32
Industrial applicability (IA)	Yes:	Claims	1-32
	No:	Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

Considering the applicant comments (done in her letter of reply dated in August 16, 2005 and the telephone conversation held on September 2, 2005), the examiner agrees that the subject-matter of claim 1 differs from document D1 in that said tunable ferroelectric thin-film dielectric layer:

1) has a dielectric constant of greater or equal to about 200 at zero bias;
2) an optimized dielectric constant of 1200;
3) a thickness of greater that 250 nm;

Therefore claim 1 is novel over the prior art at hand.

However, the examiner considers that the subject-matter of independent claim 1 is not inventive (Article 33(1) and (3) PCT) for the following reasons:

a) in the description, it is not disclosed that a dielectric constant of 200 at zero bias is used for the tunable ferroelectric thin-film dielectric layer. In page 5, line 21 refers to an dielectric constant equal or bigger than 100 not than 200. Furthermore, if the claims refers to a dielectric constant "greater" than 200, document D2 (as the applicant refers in her communication) "D2 discloses that the tunable dielectric has a dielectric constant of about 500 at zero bias voltage", then person skilled in the art would consider as a normal design option to choose another dielectric with a higher dielectric constant in order to reduce the insertion losses.

b) It is not clear from the wording of the claim, what an "optimized dielectric constant" means. Document D1 refers to a dielectric constant of approximately 100, but the fact of using another dielectric constant provides no surprising effect to the invention. The person skilled in the art knows that in order to reduce the insertion losses, the choice of a high dielectric constant for the ferroelectric thin-film is a good option.
Even more, it is not clear what is an optimized dielectric constant of 1200. Document D1, page 879, right-hand column, lines 23-26 refers: "A DC field applied between the ground

planes and the signal strip of the CPW, changes the permittivity of STO, and hence also the capacitance of the capacitors". Therefore, the person skilled in the art would consider to increase the dielectric constant of the ferroelectric thin film layer applying a DC field.

c) It is not disclosed in the description that the thickness of the ferroelectric thin-film layer should be "greater than 250 nm". In the description, page 5, line 21, the thickness of the dielectric layer is 400 nm, which is obviously greater than 250 but is considered as a range selection avoiding the subject-matter of document D1 and without providing unexpected effects or properties in relation to the rest of the range.
Document D2, page 7, line 22-24 refers to "a thickness (of the dielectric film) of 10 micrometer. However thin and thick films of the tunable dielectric material can be used".

Based on the previous comments, the examiner considers that the subject-matter of independent claim 1 lacks inventive step.

The same reasoning applies mutatis mutandis to the subject-matter of independent claim 31, rendering this claims as not inventive.

Re Item VIII

Claims 2, 14, 16, 17, 20-22, 25, 26, 29 do not follow the requirements of Article 6 PCT because they are not clear:
- Claim 2 refers to the previous claim 5. The attention of the applicant is required to the fact that mils is not the same measure as mm. The applicant is required to delete or rectify this claim in order to make it consistent with the description.
-Claims 14 and 16 refer to a central signal strip where in none of the previous claims (neither in claim 13, nor in 1) this kind of strip is referred.
- Claim 17 refers to a spacing where no previous definition or reference has been done.
- Claims 20 and 21 refers to a method claims and not to an apparatus claim.
- Claim 22 refers to a patterned bottom metallic layer, where no reference has been done to a patterned bottom layer.
- Claims 25 and 26 attempt to define the subject-matter in terms of the result to be achieved. Such a formulation is not allowable because it appears possible to define the subject-matter in more concrete terms, viz. in terms of how the effect is to be achieved.

- Claim 29 refers to a ground and to a conductor where no previous definition has been done.

1. A varactor shunt switch for microwave applications, the varactor shunt switch comprising:

a high resistivity silicon layer;

a silicon oxide layer on said high resistivity silicon layer;

an adhesion layer on said silicon oxide layer;

a metallic layer on said silicon oxide layer;

a tunable ferroelectric thin-film dielectric layer on said metallic layer, wherein said tunable ferroelectric thin-film dielectric layer has a dielectric constant of greater or equal to about 200 at zero bias, an optimized dielectric constant of 1200, and a thickness of greater than 250 nm; and

a top metal electrode on said tunable ferroelectric thin-film dielectric layer, wherein said top metal electrode defines a coplanar waveguide transmission line.

2. The varactor shunt switch of claim 1, wherein said high resistivity silicon layer has a thickness of about 20 mm.

3. The varactor shunt switch of claim 1, wherein said high resistivity silicon layer has a resistivity of > 1 kΩ-cm.

4. The varactor shunt switch of claim 1, wherein said silicon oxide layer has a thickness of about 200 nm.

5. The varactor shunt switch of claim 1, wherein said adhesion layer comprises of titanium.

6. The varactor shunt switch of claim 1, wherein said adhesion layer has a thickness of about 20 nm.

7. The varactor shunt switch of claim 1, wherein said metallic layer further comprises:

a gold layer on said adhesion layer; and
a platinum layer on said gold layer.

8. The varactor shunt switch of claim 7, wherein said gold layer has a thickness of about 400 nm

9. The varactor shunt switch of claim 7, wherein said platinum layer has a thickness of about 100 nm

10. The varactor shunt switch of claim 1, wherein said metallic layer has a thickness of about 500 nm.

11. The varactor shunt switch of claim 1, wherein said metallic layer is deposited and lifted off by electron beam deposition and standard lift-off photolithography.

12. The varactor shunt switch of claim 1, wherein said metallic layer is deposited and lifted-off by sputtering and standard lift-off photolithography.

13. The varactor shunt switch of claim 1, wherein said metallic layer comprises of at least two ground conductors and a shunt conductor.

14. The varactor shunt switch of claim 13, wherein said central signal strip has a width of about 50 μm.

15. The varactor shunt switch of claim 13, wherein said at least two ground conductors have a width of about 150 μm.

16. The varactor shunt switch of claim 13, wherein said metallic layer has a spacing between said central signal strip and said at least two ground conductors of about 50 μm.

17. The varactor shunt switch of claim 13, wherein said metallic layer has a spacing that has a geometric ratio equal to about 0.333 of said coplanar waveguide transmission line.

18. The varactor shunt switch of claim 1, wherein said tunable ferroelectric thin-film dielectric layer is comprised from one of barium strontium titanium oxide, strontium titanate, or combinations of any other nonlinear electric field tunable dielectric thereof.

19. The varactor shunt switch of claim 1, wherein said tunable ferroelectric thin-film dielectric layer is comprised of barium strontium titanium oxide.

20. The varactor shunt switch of claim 1, wherein said tunable ferroelectric thin-film dielectric layer is deposited using pulsed layer deposition.

21. The varactor shunt switch of claim 1, wherein said tunable ferroelectric thin-film dielectric layer is deposited using RF sputtering.

22. The varactor shunt switch of claim 1, wherein a varactor area of said varactor shunt switch is defined by the overlap of said top metal electrode and said patterned bottom metallic layer.

23. The varactor shunt switch of claim 22, wherein said varactor area is between about 1 μm^2 to about 500 μm^2.

24. The varactor shunt switch of claim 22 has a shunt resistance equal to one divided the product of ω, the capacitance of said varactor area and the loss-tangent of the ferrroelectric thin-film.

25. The varactor shunt switch of claim 24, wherein said shunt resistance models the lossy nature of said varactor.

26. The varactor shunt switch of claim 1, wherein said varactor shunt switch is normally in an "OFF" state.

27. The varactor shunt switch of claim 1, wherein said coplanar waveguide transmission line has about 40 to about 50 Ω characteristic impedance.

28. The varactor shunt switch of claim 1 has an area of approximately 450 μm by approximately 500 μm.

29. The varactor shunt switch of claim 1 has a parasitic series resistance when a signal is shunted to ground equal to the length of the line shunting to ground divided by the product of the conductivity of said metallic layer, the width of the conductor and the thickness of the conductor.

30. The varactor shunt switch of claim 1 has a parasitic line inductance equal to the characteristic impedance of said coplanar waveguide transmission line divided the product of 2π and the operating frequency multiplied by the sine of the product of 2π and the length of the line shunting to ground divided by the guide-wavelength.

31. A method of fabricating a varactor shunt switch, the method comprising:
depositing an adhesion layer on a high resistivity silicon substrate by electron-beam deposition and lift-off photolithography;

depositing a metallic layer on said adhesion layer by sputtering and lift-off photolithography;

covering said metallic layer with a layer of ferroelectric thin film by RF sputtering, wherein said metallic layer comprises of at least two ground conductors and a shunt conductor and said layer of ferroelectric thin-film has a dielectric constant of greater or equal to about 200 at zero bias, an optimized dielectric constant of 1200, and a thickness of greater than 250 nm;

topping said layer of ferroelectric thin film with a top metal electrode by sputtering and lift-off photolithography, wherein said top metal electrode comprises of at least two ground conductor and a center conductor; and

capping said top metal electrode with a coplanar waveguide transmission line comprised of at least two ground conductors and a signal strip.

32. The method of fabricating a varactor shunt switch of claim 41, further comprising:

tuning the capacitance of said varactor shunt switch by applying a dc electric field between said ground conductors of said metallic layer and said top metal electrode and said signal strip of a coplanar waveguide transmission line.